11 Why I Am Optimistic About the Future

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This chapter discusses three areas. The first is the President's FY 2001 R&D budget request, which envisions another century of progress for science and technology. Second, I will discuss some concerns about developments that could impede progress, specifically the Department of Defense's (DoD) R&D funding trends and our continuing inability to diversify the science and technology work force. Finally, I will give a snapshot of why I am optimistic about the future, and what I think we all should do—government, industry, and academia—to get the most from science and technology in the 21st century.

The Administration's FY 2001 R&D Budget Request

President Clinton and Vice President Gore have proposed a record-setting science and technology budget to Congress for FY 2001. The centerpiece is a nearly $3 billion increase in the 21st Century Research Fund (roughly the "fundamental" half of federal R&D activities) to address three critical national concerns. First, it funds the creative efforts that maintain our leadership in science and technology. Second, it funds the stream of innovation that ensures continued prosperity in the 21st century. Finally, it begins to restore the balance between biomedical research and the rest of our R&D portfolio. This balance underlies our progress toward national goals such as promoting long-term economic growth that creates high-wage jobs; sustaining a healthy, educated citizenry; enhancing national security and global stability; and improving environmental quality.

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The FY 2001 budget request for R&D continues the important R&D trends established by the President and Vice President, and raises the bar a bit. This is the eighth consecutive year that the President and Vice President have proposed increased investments in civilian research and development, which is up 43 percent during this Administration. In the FY 2001 budget, the 21st Century Research Fund grows by seven percent. The President's budget boosts funding for basic research by $1.3 billion. Since 1993, funding for basic research is up 52 percent. R&D support to universities increases eight percent ($2.1 billion), contributing to a 50 percent increase since 1993. And, perhaps most importantly, this budget substantially improves the balance in our R&D portfolio in recognition of the interdependence of scientific disciplines.

It is especially significant that the President's R&D request increases university-based research that will (1) ensure a strong science and technology (S&T) work force in the 21st century, (2) help close the opportunity gap, and (3) provide economic opportunity for all Americans. It also ensures the U.S. position as the world leader in science and technology, at least for the immediate future.

The President's budget also provides a substantial increase for most of the R&D agencies, including an additional $1 billion (a six percent increase) at the National Institutes of Health (NIH) and an extra $675 million (a 17 percent increase) at the National Science Foundation (NSF). The President has also requested major funding increases for S&T programs at the Departments of Energy, Commerce, Agriculture, Transportation, Interior, and Education, the National Aeronautics and Space Administration, and the Environmental Protection Agency.

Within the balanced R&D portfolio we are also proposing some very important interagency initiatives. In the area of energy, there is a new focus on biofuels; on developing clean, efficient energy technologies for the burgeoning international markets; and on strong support for research to improve domestic housing and make cleaner cars. We have a targeted effort to understand solutions for environmental policy challenges such as hypoxia, harmful algal blooms, and biodiversity loss. We are moving our robust global-change research program into understanding carbon uptake and storage in terrestrial systems and to take stock of what a changing hydrological cycle might mean for the planet. We have continued our strong support for education research. And among our efforts to address 21st century threats, we have proposed a new Institute for Information Infrastructure Protection, which is a new partnership with industry.

I want to highlight just two interagency initiatives. First, the FY 2001 budget proposes a bold new initiative in nanotechnology research. This effort, known as the National Nanotechnology Initiative, will provide a $225 million increase in the emerging fields of nanoscience and nanoengineering. This increase nearly doubles the current federal investment. Roughly 70 percent of this new funding will go to university-based research. This investment will also help meet the growing demand for workers with nanoscale science and engineering skills. The Administration believes that nanotechnology will have a profound impact on our economy and society in the early 21st century, perhaps comparable to that of information technology or cellular, genetic, and molecular biology. It is likely to impact all these fields and many more.

The second interagency initiative the President highlighted in his S&T budget will build on our national investments in fundamental research in information technology (IT) with a $600 million increase. The basic goals driving our Information Technology for the Twenty-First Century initiative include:

- long-term information technology research that will lead to fundamental advances in computing and communications;

- investments in advanced computing for science, engineering, and national goals; and

- study of the economic and social implications of the information revolution and training the IT workforce, with a special emphasis on ensuring that all Americans can benefit from these technologies.

The President's S&T budget plots a bold course of strategic growth and prosperity through discovery. Many people, especially the President and the Vice President, worked very hard to present this $3 billion increase to Congress with the hope, even the expectation, that we could work with the membership on a bipartisan basis to see it successfully enacted.

That is why it is especially galling this year to find ourselves—yet again—confronted with congressional budget resolutions that threaten our ability to adequately fund the S&T investments needed to carry our nation into the 21st century. There are Members of Congress in both parties who are trying to help. Congressmen Rush Holt (D-NJ) and Vernon Ehlers (R-MI) and Senator Edward Kennedy (D-MA) have worked to add $1 billion for R&D to the Budget Resolutions. But the

Budget Committee Chairmen have established shortsighted spending priorities and budget ceilings that could translate into severe cuts for many vitally important programs.

If allowed to proceed unchecked, Congress could stall our progress toward national goals and balance in a healthy R&D portfolio precisely at the moment in history when we can best afford to invest in America's future. As of the time this is written, the Republicans' budget plans reduce the discretionary accounts by $17 billion below the President's request. Senator Pete Domenici (R-NM) and Rep. John Kasich (R-OH) indicated that they would spend more on defense (about $500 million higher than the President requested), and would equal or beat the President's request on education, veterans' medical care, and NIH. The result is that all the rest of nondefense discretionary spending must be cut deeply in order to meet the ceiling imposed by the Budget Committee Chairmen. Our estimates show this will need to be about ten percent. Clearly, as President Clinton recently stated, a budget that shortchanges critical national priorities, like R&D, is not the best path for our nation. The American people agree with the President on this.

We must not become complacent in the face of "sense of the House" or "sense of the Senate" resolutions to provide increases to Function 250 that do not meet the President's request. We should remember that our S&T budget is not just a balance sheet, it's a blueprint for our future. How regrettable then to see Congress falling back into its familiar, nasty partisanship proposing a flawed budget that is a blueprint for chaos. The congressional budget resolution, based on irresponsible tax cuts, would make sharp reductions in key S&T priorities and shortchange critical national investments. It targets valuable science programs that are vital in keeping the United States in the front ranks of research and innovation. Such a budget would be unrealistic, unwise, and unconscionable and would fail America's scientists and engineers by pretending they should do more with less.

There is a lot of work to be done if we want a good R&D budget at the end of this appropriations cycle. We all need to become deeply involved in this effort.

Concerns About the Future of S&T

We must make sure that science serves society. As the Vice President says, our newest technologies must help advance our oldest and most cher-

ished values. After addressing this issue, I will return to the R&D budget and take a brief look at R&D investments by the Department of Defense (DoD) in particular. I will then suggest some goals for consideration.

Science and Societal Values

Now is the right time to talk about science and societal values because, by any measure, it is an extraordinary time of achievement and promise in science and engineering. There is a long and intriguing list of possibilities that are suddenly close to reality. Things that a decade ago were still considered science fiction are now happening. It can be a truly great "century of discovery." The accelerating pace of discovery generates a sense of even greater urgency to ensure that this accumulated knowledge is used to create opportunities for society and to make this next 100 years a great "century of opportunity" as well.

One way to do this is to better couple the laboratory to the factory through public-private cooperation. The Clinton-Gore Administration has worked very hard to establish public-private partnerships—such as the Partnership for a New Generation of Vehicles—that attempt to better connect the fruits of R&D with economic, health, and other social benefits. But we have also recognized the need to better understand the impact of rapid technological change on people's lives and on their attitudes. For this reason, the Administration has set aside funds to study the ethical, legal, and social implications of our science and technology endeavors. A recent article by one of society's most astute technopioneers, Bill Joy, a founder of Sun Microsystems, made us all stop and think. In his article titled "Why the Future Doesn't Need Us," (see chapter 3) he made us ponder the possibility that society could move beyond creating "virtual reality" to creating a form of "real virtuality," in which we humans are no longer necessary. His comments were viewed by some as suggesting that our own technological progress could turn on us.

However, I believe it is more likely he had Albert Einstein's admonition in mind: "Knowledge of what is does not open the door directly to what should be." Creating continuous new knowledge in science and technology without knowing where it will lead is a visionary path. But creating societal opportunities with our current science and technology is a humane and appropriate path. This is not a choice of one road or the other like that famous Robert Frost poem. We must pursue both and designate resources for both journeys.

Whenever I hear someone talk about two paths, I think of Yogi Berra's advice: "When you come to a fork in the road, take it." Truly, I believe that asking both what is possible and what is sensible is the only thing that can save us from some of the anti-technology fervor that has gripped Europe and is looming here on issues such as genetically modified organisms, cloning, and stem cell research. And this is only the beginning.

Another area where technology touches our lives—and our children's lives—is education. As we use science and technology to expand opportunities for the nation, just as significantly, we need to focus on how science and technology can be used to create opportunities for individual growth. For example, we are close to realizing our goal to equip every school in the nation with Internet access. It is, of course, important to ask how best to use this technology for learning. But unless the teachers and students have access, there is no way to find out. Through partnership with the private sector, we can empower every school child in the nation to learn information-age skills.

And we had better keep that goal front and center if we expect our country's future to outshine its past. The increasing economic role of science, technology, and engineering has, in turn, increased demand for all types of scientific, technical, and engineering workers, from technicians to Ph.D. research scientists and engineers. We have some serious issues to address in that regard.

The S&T Work Force

A recent report from the National Science and Technology Council called *Ensuring a Strong U.S. Scientific, Technical, and Engineering Workforce in the 21st Century* reaches two fundamental conclusions about our science, technology, and engineering work force. First, these workers are essential to both the private and public sectors. In the private sector, they help propel the economy and provide valuable services. In the public sector, they support important federal missions. Second, it is in the national interest to vigorously pursue the development of domestic science, technology, and engineering workers, both women and men, from all ethnic groups.

Science, technology, and engineering jobs present great opportunities for American workers. They are among the fastest growing in the U.S. work force. Unemployment in science and engineering occupations,

with some variability among fields, is quite low. But if current trends persist, our nation may begin to fall far short of the talent needed to spur the innovation process that has given America such a strong economy and high quality of life. The ongoing debate over H-1B visas suggests that worker shortages are limiting our economic growth. America is indeed fortunate that talented men and women from all over the world have chosen to study and work in the United States. Our leadership in S&T is largely due to this situation. But we cannot expect it to continue. We will have to do a much better job of growing our own talent, which we should do for a number of reasons.

Demographic trends also raise concerns about the nation's ability to meet its future high-tech work force needs. Historically, non-Hispanic white males have made up a large fraction of U.S. scientists and engineers. But in the 21st century this fraction of the U.S. population is projected to decrease significantly. Other U.S. population groups, such as Hispanics and African Americans, form a much smaller part of the high-tech work force, but their populations as a fraction of the U.S. population are expected to increase markedly in the next 50 years. This implies that science, technology, and engineering workers may decline as a fraction of the total work force if the relative participation of these respective groups remains unchanged. If we want a strong high-tech work force, members of all groups, including non-Hispanic white males, must participate at increasing rates. High-tech careers will have to become more attractive to everyone in our society—women and men from all backgrounds and all parts of the country.

I am concerned we are not doing enough to increase participation through the actions of government, industry, and academia. And I am worried that it seems to be getting harder, not easier, to make progress, in part due to new legal and political pressures that reduce our options.

R&D Investments in DoD

Defense funding of R&D, particularly in the nation's universities, has been a key element of America's advancement to become the world leader in science and technology. But for some time now defense-sponsored research and development has failed to keep pace with foreseeable demands of the military services, and, as a result, the innovation base is eroding.

It can be argued that some of this drop results from the Defense Department's ability to reap the benefits of an advanced commercial tech-

nology base. It has historically done much to foster this. As a December 1999 report of the Defense Science Board Task Force on Globalization and Security points out, the commercial sector is now driving the development of much of the advanced technology that is being integrated into modern information-intensive military systems.[1] But, at the same time, we have been seeing a retrenchment in corporate basic research, with both industry and the military increasingly relying on government-sponsored, nondefense basic research to provide the intellectual groundwork of their industrial research and development efforts. Moreover, we will always have defense-unique requirements that commercial technologies will not be able to fill. A fear is that failure to renew our military research and development base may leave us unprepared for future conflicts.

Cuts in DoD-sponsored R&D also undermine our historical distribution of responsibilities for stewardship of the S&T enterprise. Although DoD's support for R&D in universities is a small portion of DoD's R&D budget, it plays a crucial role in many universities' research portfolios, and it shoulders a major share of the federal government's investment in certain key fields. For example, DoD provides more than half of all federal support for electrical engineering and mechanical engineering at universities; it funds nearly half of all federal support for computer sciences and materials engineering; and it plays a strong role in several other fields such as oceanography, mathematics, aeronautical engineering, and astronautical engineering. Cuts in DoD R&D are likely to have a disproportionate impact on these fields, and that will impede our efforts to restore balance in our national R&D portfolio.

Indeed downward pressures on all of our investments have begun to show their effects in our national S&T enterprise. Over the past several decades, R&D funding has declined as a percent of the federal budget. The federal R&D budget, civilian and defense, has stagnated as a percent of the gross domestic product (GDP). Compared to our strongest economic competitors, the United States government spends less, as a fraction of GDP, on civilian R&D. (Some may well ask whether a certain percentage of GDP is the right measure. Because it provides a snapshot of our level of effort for scientific discovery against a backdrop of our total economic effort, I believe it is.)

Optimism About the Future of S&T

These problems did not arise overnight. In fact, the Administration's actions over the past seven years have helped to sustain America's ability to create and capitalize on world-class science and technology. President Clinton and Vice President Gore funded increases in the federal research and development budget even as we steadily brought the budget into balance and, ultimately, to its record surpluses today. The R&D budget has actually grown as a percentage of total discretionary spending, which is a clear indication that the Administration considers investment in science and technology a high priority for the nation. Indeed, the Administration's strong FY 2001 budget request for S&T is unprecedented.

David Gergen's editorial in the April 10, 2000, *U.S. News & World Report* warns us that we will miss Bill Clinton, and comments that the President's imagination is on fire about today's scientific and technological revolutions. Gergen has it exactly right. And there is no reason we cannot continue on the trajectory set by the Clinton-Gore budget request. Congress has the opportunity to demonstrate strong bipartisan support for S&T, as one of the clearest high-return investments for America's future.

But if we are to place federal funding for R&D on a new, upward trajectory, we will need to have a solid rationale for doing so, and we will need to set some goals. The truth of the matter is, we in America have been eating our seed corn for a long time now, and it is time to grow some more.

The private sector understands this. The direct impact of new knowledge and technologies on the economy has never been clearer. As a consequence, industry support for R&D continues to grow far faster than federal R&D funding or the U.S. economy as a whole. But industry's R&D is focused on short-term needs. Just as we have started to reinvigorate our support of the physical sciences, mathematics, computer science, and engineering to restore balance to the federal R&D portfolio, we also need to reap the rewards of fiscal discipline and get the overall federal investment in science and technology balanced and up to a level that can support a robust future economy and provide all the other social benefits our people need. So here is what I hope government, industry, and academia will work toward over the next five to ten years.

Proposed Goals

I have two proposed goals for the U.S. government. First, set a new target for R&D as a percent of GDP. Bill Clinton and Al Gore proposed a national target (public and private) of three percent. We are practically there. It is now time to stretch ourselves a bit more, particularly with respect to federal funding. We ought to consider a target, perhaps not for total federal R&D—where defense development needs will strongly influence the number—but for the 21st Century Research Fund. The Research Fund includes NIH, NSF, DoD basic and applied research, and most of the other civilian R&D programs. It is currently funded at just under 0.5 percent of GDP. In ten years, we should double that to one percent. We can argue about exactly what the right percentage should be, but we have to have a goal.

Second, while our researchers will be making extraordinary discoveries in all fields of science and engineering, we need a national challenge to galvanize Americans' interest in science and technology and encourage more young people to pursue careers in discovery. There are a number of possibilities. For example, should we colonize the Moon or Mars? A recent issue of *TIME* focused on "Visions of Space and Science" and suggested that much of America is fascinated by the latter possibility.[2] Another challenge might be: Do we need a planetary early-warning defense system to alert us to incoming asteroids? One will reach us eventually.

Perhaps we can excite young minds with target dates for one or more of the following:

- developing an integrated prediction model for the world's regional climate and weather, or eventually controlling the weather;
- establishing space-based observations of planetary systems throughout the galaxy;
- proving a final theory of the subatomic world;
- building customized chemicals and smart materials using the newest technologies;
- providing gene-based, personalized medical care, including nanorobotic systems for prevention, diagnosis, and treatment; or

- designing a mind/brain computer interface. We could use the mind to figure out how the brain works, and eventually how the mind itself works.

Others will have other ideas, perhaps better ones, for challenges that can stimulate a whole generation of young women and men to learn math and science, to get excited about careers as scientists and engineers, and to want to be a part of a peaceful and sustainable technological future. We can foresee exhilarating opportunities in biomedicine, computing and communications, climate and weather, nanotechnology, elementary particles, and cosmology. (Oh, to be young again!)

I hope industry will set some goals as well. I have three in mind: First, double your share of university-based R&D funding by 2010. If you do, you will get breathtaking research discoveries and outstanding S&T workers. It will be a good investment.

Next, take the same pledge that 25 companies—from Adobe Systems to Xerox—took April 6, 2000, at the White House. Promise to spend at least $1 million dollars, annually, for the next ten years to expand diversity in the high-tech work force. These funds will be used for a wide range of programs, including scholarships, job training, math and science programs, internships, and other programs to encourage minorities, women, and persons with disabilities to pursue science, engineering, and technical careers. Long-term commitments by the corporate community will not only promote diversity in the work force but will also help address America's need for additional skilled scientists, engineers, and technical workers.

Third, I urge companies to partner with local school boards to provide year-round, high-wage employment for math and science teachers and help recruit them. The Office of Science and Technology Policy and the National Institute of Standards and Technology will soon launch a pilot program partnering local school boards and businesses to foster high quality K–12 education. School boards and local businesses will recruit and hire math, science, and technology teachers and provide them with yearlong salaries for at least four years. Business leaders will guarantee summer employment for the teachers and provide them with the opportunity to develop innovative teaching methods reflecting real-world experience of science and technology in the workplace. Close cooperation between schools and businesses is expected to lead to additional benefits such as businesses placing volunteers in the classrooms and providing summer employment or internships for advanced students.

Last, I want to propose some changes for academia to consider. Why not set a target for increasing the number of minorities and women who graduate with S&T degrees? I suggest ten percent per year through 2010. That may not be the right number, but it can start the debate. We have to set a realistic goal. But also we cannot afford to continue to make so little progress.

How about making math and science literacy a prerequisite for graduation with a baccalaureate degree? Rather than just talk about the lack of public understanding of science and technology, universities and colleges have it within their power to do something about it.

Finally, by the year 2010, ensure that all K–12 teachers have the necessary knowledge and are well prepared to teach their math and science classes. It is time for all parts of research universities and teachers' colleges as well as schools of education within universities to work together to make sure no more students are "bored" away or "scared" away from math and science. Until this happens—and is visible in your communities—it will be hard to convince supporters that the universities really care about K–12 education.

Conclusion

The S&T compact that we often talk about requires all the parties—government, academia, and industry—to extend themselves beyond the ordinary boundaries that govern our relationships. Last year, the Vice President called on the scientific community to look for new opportunities in the new millennium. He has called for the development of a "New Compact" between our scientific community and our government based on three tenets. First, as we continue to probe the most fundamental questions of nature (and let us never be distracted from this quest), we must also do more to ensure the best use of science and technology to sustain our prosperity, create jobs, and grow the economy for the 21st century.

Second, we must make sure that we not only generate the fruits of discovery, but also share the excitement and rewards of discovery. That means working to ensure that more people have access to technology and to rewarding careers in science and technology.

Finally, as I mentioned above, we must do more to make sure our newest technologies help advance our oldest and most cherished values. We have a weighty responsibility in this area, and, once again, I chal-

lenge all of us to become civic scientists and engineers, all deeply engaged in using the knowledge and tools of our profession to make a better world.

If science and technology hold the key to prosperity, health, and security in the 21st century, we must be bolder in the demands we make of ourselves and the expectations we hold for all stakeholders in the enterprise. Only by acting together, can we constitute a whole greater than the sum of our parts and achieve the full potential of this great nation.

Endnotes

1. Hicks, Donald A. *Report of the Defense Science Board Task Force on Globalization and Security.* Defense Science Board. Washington, DC. December 1999.
2. *TIME.* April 10, 2000. Vol. 155, No. 14, Visions 21.